Notes on diving behaviour of Hardhead *Aythya australis* in a sewage pond

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Abstract
Observations of the diving behaviour of Hardhead *Ayhtya australis* on a sewage pond were carried out over a two-day period. The length of the recovery period between dives did not influence the duration of the following dive, and likewise, the length of the recovery period was not influenced by the duration of the preceding dive. The length of dives and recovery periods varied significantly among individuals. Other factors that may influence diving behaviour, such as water depth and temperature, warrant further investigation. (*The Victorian Naturalist* **123** (1), 2006, 38-40)

Introduction

Little is known about the diving behaviour of Hardhead *Aythya australis*. Frith (1982) noted that individuals often stayed under water for around one minute, and could emerge up to '30 or 40 yards [18–27 m]' from where they dived below water. Marchant and Higgins (1990) suggested birds often swim up to 40 m under water using their feet, although they did not provide any data to support this supposition. This paper presents data on the dive-duration (time under water) of Hardhead and the time spent between dives (inter-dive interval). It also examines whether or not these parameters varied between individuals. The relationships between the inter-dive interval and the associated previous dive-duration, and the inter-dive interval and its following post dive-duration are investigated as well.

Methods

Study site

All observations were made at Pond Nine, Lake Borrie, at the Western Treatment Plant in Victoria. This pond covers an area of 109 ha, and the average water depth is 60 cm (Cartwright 1996, unpublished data). Further details about the site can be found in Hamilton and Taylor (2004) and Hamilton *et al.* (2002; 2004).

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Sampling protocol

Sampling was conducted on July 8 and 9, 1999. All observations were made from the embankment of the pond using either binoculars (Carton® 10 x 50) or a telescope (Leica® Televid 77, 20–60 x zoom magnification), depending on the distance from the focal bird (distance ranged from approximately 25–300 m). Focal individuals were chosen haphazardly. On the first and second dates, respectively, 95 and 35 dive-times were recorded. Likewise, 94 and 36 inter-dive intervals were observed. Birds that were near other diving Hardheads were not chosen as focal individuals, to avoid confusion when identifying emerging birds. In an attempt to reduce the occurrence of repeat sampling, observations were made on different parts of the lake. All observations were made within 2 h either side of midday. Another study at the same site demonstrated that the time Hardheads spent feeding did not change over this period (Hamilton *et al.* 2002).

Statistical analysis

All statistical analyses were performed in the statistical package GenStat (Version 6.1, Lawes Agricultural Trust, IACR-Rothamsted). The correlations between dive duration and post-dive duration, and pre-dive duration and dive duration, were tested using Pearson's product moment coefficient (Pearson 1920). The null-hypothesis that the correlation coefficient of the population (r) was not significantly different from zero was tested using the two-tailed F distribution test described by Cacoullos (1965).

The effect of individuals on dive-duration and inter-dive interval was examined using restricted maximum likelihood (REML) (Patterson and Thompson 1971; Hepworth and Hamilton 2001). REML is a more general procedure than ANOVA, and reduces to ANOVA in simple balanced cases. This design was unbalanced because the number of birds observed varied between dates, and the number of observations made varied between birds. Date was modelled as a random effect, which is analogous to a block effect in ANOVA. The mean percentages were compared using a Wald statistic, which is analogous to the variance ratio used to compare treatments in ANOVA, though it has an asymptotic chi-squared distribution rather than an F distribution. The inter-dive interval data were $\log_{10}$ transformed to ensure homoscedasticity.

Results

The mean dive duration was 13.7 s (SE = 0.04 s, min.–max. = 4.0 s–25.8 s), and the mean inter-dive interval was 10.6 s (SE = 0.41 s, min.–max. = 2.0 s–47.0 s). Dive duration was not significantly correlated with the inter-dive interval before the dive ($r = 0.166$, $P > 0.05$, $df = 101$) or the inter-dive interval after the dive ($r = 0.197$, $P > 0.05$, $df = 111$). In other words, length of the rest period did not influence the length of the following dive, and likewise, the length of the rest period was not dependent upon the duration of the preceding dive. There was a significant individual effect with respect to both dive-duration ($P < 0.001$, $df = 37$) and inter-dive interval ($P < 0.001$, $df = 39$). That is, there was significant individual variation in the length of dives and the post-dive inter-dive interval.

Discussion

Most studies on the diving behaviour of pochards *Aythya* spp have been conducted in artificial environments such as dive-tanks (Bevan and Butler 1992; Lovvorn 1994, Stephenson 1994; Parkes *et al.* 2002). In particular, there are little data on the length of dives by different species and in natural environments. The mean dive-duration observed for Hardhead in our study (13.7 s) was less than the mean times observed for pochards on lakes elsewhere. The mean dive-durations for male and female Greater Scaup *Aythya marila* at Lake Mývatn in Iceland were 22.8 s (SE = 0.39s) and 23.4 s (SE = 0.20s) respectively (Magnúsdóttir and Einarsson 1990). At the same site, male Tufted Ducks *Aythya fuligula* dived for 17.8 s (SE = 0.27 s), and females, 18.8 s (SE = 0.25 s). Lake Mývatn is relatively shallow, with a maximum depth of around 5 m (Magnúsdóttir and Einarsson 1990). From the data available, it is not possible to determine if the observed differences in dive-times are a result of species or environmental factors, such as water depth and temperature, or a combination of these.

It is possible that water depth plays a role in determining the dive-duration of Hardheads, and that studies at deeper water bodies, where Hardheads are known to forage (Frith 1982), will reveal different times from those observed here. A study on dive-times of Canvasbacks *Aythya valisineria*, Redheads *A. americana*, and Lesser Scaup *A. affinis* revealed a significant effect of water depth (Lovvorn 1994). In a 1.2 m deep tank, the respective dive-durations for these species were 8.2 s, 6.2 s, and 8.3 s, and in a 2 m tank they were 13.3, 8.6, and 11.2.

Significant variation between dive-duration of individuals has not been recorded before from field studies on diving-ducks. The significant effect observed here could mean that individuals have different foraging strategies, or it may indicate that there were differences in water depth or foraging patch quality in the pond. There is insufficient information on the spatial distribution of benthos or variation in water depth to test these hypotheses.

Previous studies on pochards and other diving-ducks in natural and artificial environments have demonstrated a positive relationship between dive-duration and the length of the subsequent inter-dive interval (Beauchamp 1992; Stephenson 1994; Malhotra *et al.*1996; Parkes *et al.*2002). More specifically, Parkes *et al.* (2002) found that the shape of the oxygen uptake curve and the mean volume of uptake were dependent on the length of the preceding dive, with more oxygen required for recovery after longer dives. The lack of a relationship between dive-duration and post-dive duration in our study could mean that the ducks were not only paying the oxygen debt from the previous dive, but were

devoting some time to other activities such as scanning for predators or avoiding interactions with other ducks.

Dedication

This paper is dedicated to the memory of the late Emily Natalie Levu Hamilton.

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Male Hardhead *Aythya australis*. Photograph by Geoffrey Dabb.